Enamel

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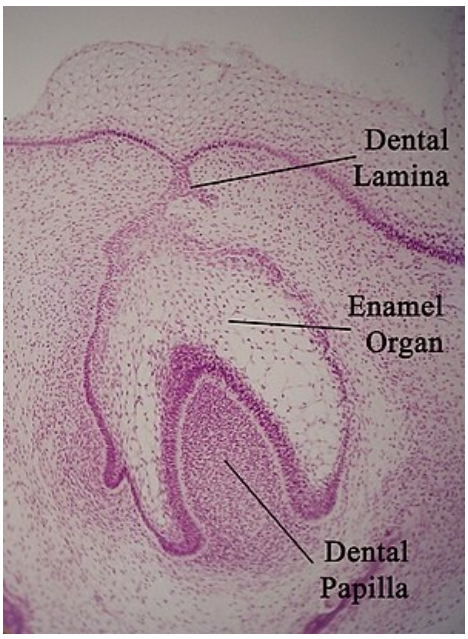
General Properties



Tooth development

'*Enamel* is of ectodermal origin. It is produced by internal ameloblasts of the enamel organ. It is the hardest tissue in the human body, which is also due to the fact that it is the **most mineralized tissue** in the body. The main mineral is fluorohydroxyapatite. The enamel has a bluish to slightly yellowish color.

Composition

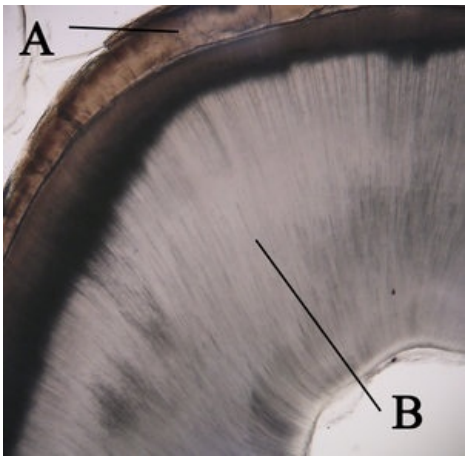
Enamel belongs to the connective tissues. It therefore consists of cells and intercellular matter.

Enamel cells

The cellular component is represented only during the period of enamel development in the form of external and internal ameloblasts of the enamel organ, which disappear at the moment of completion of the development of the external shape of the enamel and give rise to the *cuticule dentis (*Nasmyth's membrane*).*

Intercellular mass

The intercellular mass contains a fibrous and amorphous component.



Tooth section: A – Enamel, B – dentin

Fibrous folder

The fibrous component is absent in this case.

Amorphous component

The amorphous component is represented by **inorganic compounds**': water, hydroxyapatite, other minerals and an **organic component** (glycosaminoglycans, proteoglycans, glycoproteins).

Water	Hydroxapatite and other minerals	Organic components
11%	87%	2%

Water is present in enamel as free (bound to organic matter) or bound to crystals. Enamel can absorb water together with ions in a humid environment. On the contrary, it releases water in a dry environment. Teeth that are not sufficiently exposed to the environment of the oral cavity (xerostomia, sleeping with the mouth open) have a chalky color. For that reason, it is also necessary to choose the color of the prosthetic or conservation restoration on a dry tooth.

Organic components are represented by 40% lipids and 58% proteins. Enamel prisms are covered with a layer of heterogeneous afibral proteins, which include enamelin and amelogenin. Other enamel proteins include tuftelin. Enamel also contains the glycosaminoglycans *keratan sulfate* and *chondroitin sulfate*.

'*Inorganic material* is made up mainly of hydroxyapatite or other types of calcium phosphate. To a lesser extent, it is also made up of calcium carbonate ($CaCO_3$), calcium fluoride (CaF_2), magnesium carbonate ($MgCO_3$) and other minerals .

Hydroxyapatite

Hydroxyapatite can be expressed by the general formula $M_{10}(XO_4)_6(Y)_2$. In the case of hydroxyapatite, the letter M is represented by Ca^{2+} and XO_4 ions, PO_4^{3-} anions. Individual ions forming hydroxyapatite can be exchanged for other ions, which will affect the properties of the substituted compound. We can express this by the following notation: $Ca_{10-x}\ Na_x(PO_4)_{6-y}(PO_4)_z(OH)_{2-u}\ (F)_u$. The following table shows the representation of the most common substituents.

M	XO4	Y
Ca^{2+}	PO_4^-	OH^-
On^+	CO_3^{2-}	F^-
K^+	$HPO4^-$	Cl^-
$Sr2^+$		
$Br2^+$		

In the case of substitution for Na^+ and OH^-, these are stoichiometric substitutions, while in the case of PO_4^{3-} this is a non-stoichiometric type of substitution. The most common substituted form is the carbonate hydroxyapatite $Ca_{10}(PO_4,CO_3)_6(OH)_2$. The presence of CO_3^{2-} disturbs the regular arrangement in the crystal and thereby increases its solubility. Another common form is flouroapatite $Ca_{10}(PO_4)_6(F)_2$. The presence of fluoride anion significantly reduces the solubility of enamel. Enamel with this content normally dissolves at pH 4.5 (compared to the usual pH 5.5 in the case of hydroxyapatite). The following table shows the representation of other common forms of calcium phosphate in enamel.

A form of calcium phosphate	Formula
β - Tricalcium phosphate (TCP)	$Ca_3(PO_4)_2$
Brushit	$CaHPO_4.2H_2O$
Octacalcium Phosphate (OCP)	$Ca_8(HPO_4)_2(PO_4)_4$
Amorphous calcium phosphate	$Ca_x(PO_4)_y.nH_2O$

Structure

The basis of the enamel structure are enamel crystals. The so-called aprismatic enamel occurs in the gingival third of the tooth and on the surface of the temporary teeth.

Enamel Prism

Crystals are 160 nm long and 40–70 nm wide depending on the stage of development and localization. Each crystal is surrounded by an envelope of proteins and lipids. Around 100 crystals are combined into an enamel prism (so-called enamel prism). In the core of the prism, the individual crystals are oriented parallel to the long axis of the prism. (These are polygonal, arcaded and oval.) They run from the dentinovitreous border perpendicular to the surface. Each prism is surrounded by a thin membrane (*membrana prismatis*) with a thickness of 0.1–0.2 µm. The prisms are embedded in the so-called interprismatic substance. The intraprismatic substance is less mineralized and the hydroxyapatite crystals are oriented perpendicular to the long axes of the prisms. The prisms combine into larger bundles, which can be cylindrical, keyhole, or horseshoe shaped.

The prisms always run perpendicular to the dentino-enamel border. Therefore, in the area of the bumps, they run almost vertically, and in the neck area, on the contrary, horizontally to slightly apically. At the same time, the prisms have an ace shape. This shape is advantageous because of the axial load on the tooth, as the ace-shaped course simultaneously enables the effective transfer of force to the dentin without damaging the enamel structure. **If we perform a longitudinal grinding of the tooth, we will never find the prisms in their entire course (as they have an ace-shaped course). As a result of this course, the so-called Hunter-Shreger stripes** appear on the ground tooth when observed with a polarizing microscope . They are composed of transverse diazons and longitudinal parazons that form an angle of 40%. This angle is effective for axial tooth load transfer.

Other optical phenomena include the so-called *Retzius stripes*. These strips, on the other hand, are concentrically arranged, because they represent the unevenly occurring gradual mineralization of the enamel.

Prismatic enamel

This type of enamel is characterized by a structure with the absence of prisms. It has the same chemical composition as the rest of the enamel, but is less mineralized and contains disordered crystals. Prismatic enamel occurs on the surface of the temporary teeth and in the gingival third of the teeth. It is formed as the last product of ameloblasts, which subsequently participate in the formation of *Nasmyth's membrane*. Nasmyth's membrane is an approximately 3 µm thick membrane that covers the surface of the tooth before it erupts into the oral cavity and shortly after eruption. As a result of attrition, it disappears from the surface of almost the entire tooth during life and remains only in the gingival third of the tooth.

Links

Related Articles

- Dentinum
- Cementum

- Hard dental tissues
- Teeth

External links

- HORKÝ, Drahomír and Květoslava NOVÁKOVÁ. *Morphology of the orofacial system for dental students* [online] . 2nd edition. Published online. 2011. Also available from < https://mefanet.upol.cz/clanky.php?aid=58 > (https://mefanet.upol.cz/clanky.php?aid=58). ISBN 978-80-244-2702-7 .
- Tooth (human) (English Wikipedia) (https://en.wikipedia.org/wiki/Human_tooth)

References

- KLIKA, Eduard. *Histologie pro stomatology.* 1. edition. Avicenum, 1988. 448 pp.
- MINČÍK, Jozef. *Kariologie.* 1. edition. Stomateam s.r.o, 2014. 255 pp. ISBN 978-80-904377-2-2.